

Original Contributions

Risk Factors for Persistent Middle-Ear Effusions

Otitis Media, Catarrh, Cigarette Smoke Exposure, and Atopy

Michael J. Kraemer, MD; Mark A. Richardson, MD; Noel S. Weiss, MD, DrPH; Clifton T. Furukawa, MD; Gail G. Shapiro, MD; William E. Pierson, MD; C. Warren Bieman, MD

• To ascertain risk factors for persistent middle-ear effusions (PMEE), we interviewed the parents of two groups of children. The first consisted of 76 children with PMEE who were admitted to the hospital for tympanostomy-tube insertion. The second, a control group, consisted of 76 children admitted for other types of surgery, who were matched for age, sex, season, and surgical ward. Nearly all (97%) of the children admitted for insertion of tympanostomy tubes had one or more episodes of suppurative otitis media. Only 59% of the control children had previous ear infections.

Children with PMEE were more likely to have had previous ear infections, catarrh, exposure to cigarette smoke, and atopy. These factors should be included in the medical history of children with PMEE.

(JAMA 1983;249:1022-1025)

MIDDLE-EAR effusions are common in children, particularly after a suppurative middle-ear infection.^{1,2} Most effusions resolve after several weeks, but some persist relentlessly,^{3,4} causing hearing loss⁵ and associated language, behavioral, and learning deficits.^{6,7} Each year in the United States, an estimated 1 million operations take place in which tympanostomy tubes are inserted for persistent middle-ear effusions (PMEE).⁸

Several factors may affect the frequency of middle-ear disease: age,^{9,10}

sex,^{11,12} season,¹³ socioeconomic class,¹⁴ exposure to other children,¹⁵ catarrh,¹⁶ positional feeding styles,¹⁷ atopy,^{18,19} and a family history of ear disease.²⁰ In this study, we examined the association of these factors with the persistence of middle-ear effusions.

METHODS

The Research Committee and the Human Rights Committee at the Children's Orthopedic Hospital and Medical Center, Seattle, reviewed and approved these procedures. All parents gave informed consent before interview.

Case Selection

From June through October 1981, two general pediatric otolaryngologists performed 96 bilateral myringotomy and

tympanostomy-tube insertions (BMT) for PMEE. Children were treated surgically if they had bilateral effusions (with pneumatic otomicroscopy and tympanometry) that did not resolve after eight or more weeks of medical therapy, and which produced a hearing loss of 25 dB or greater. These children were admitted to a short-stay ward at the Children's Orthopedic Hospital and Medical Center for surgery. Their parents were asked to participate in an interview about risk factors for ear disease. We interviewed 76 parents of the 96 patients with PMEE. Of the 96 patients' families, two were excluded because they did not speak English, and 18 could not be reached.

Control Selection

Twelve physicians (four general surgeons, one urologist, one ophthalmologist, two dental surgeons, and four cardiologists) allowed us to contact parents of their patients admitted during the same period to the same short-stay surgery ward. From this group of 202 children, control subjects were matched to PMEE cases by age (± 1 year), sex, and month of surgery. Ninety-five patients were matched initially, but 14 could not be contacted. Five interviews were excluded because of current middle-ear effusions or past ear surgery.

Clinical Characteristics of Cases and Control Subjects

Twenty-one patients with PMEE (21.6%) had previous bilateral tympanostomy-tube insertions (range, one to nine). Two patients with PMEE had Down's syndrome and two had cerebral palsy. In

From the Divisions of Otolaryngology (Dr Richardson) and Allergy (Drs Kraemer, Furukawa, Shapiro, Pierson, and Bieman), Children's Orthopedic Hospital and Medical Center, and the Departments of Otolaryngology, Pediatrics, and the School of Public Health (Dr Weiss), University of Washington School of Medicine, Seattle.

Reprints not available.

The 76 control children, the reasons for admission were inguinal hernia repair (20), cardiac catheterization (17), biopsy or foreign-body removal (eight), umbilical epigastric or diaphragmatic hernia repair (six), orchiectomy (six), hydrocele repair (three), dental caries debridement (three), cataractomy (one), esotropia repair (one), and proctocolony (one). Down's syndrome occurred in only one control child who had cytotoxic congenital heart disease. No other medical condition occurred more than once in either group.

Interview

Parents were interviewed within eight weeks of the scheduled surgery for the following information: (1) racial background, (2) family size, (3) health insurance status, (4) infant care and feeding practices, (5) household exposure to cigarette smoke, (6) frequency of suppurative otitis media (symptomatic ear infection treated with antibiotics), (7) frequency of eczema (audible nasal breathing with rhinorrhea), (8) atopy (defined as one or more of the following disorders during the preceding 12 months: seasonal rhinitis [sneezing or summer sneezing, nasal itching, rhinorrhea, and nasal congestion], asthma [present wheezing, which improved with use of bronchodilators], eczema [recurrent pruritic dermatitis, which improved with topical steroid therapy]), (9) family history of atopy, and (10) family history of significant middle-ear disease (six or more episodes of suppurative otitis media, or previous insertions of tympanostomy tubes).

Analysis

The likelihood of PNEE developing with a certain exposure was expressed as the relative risk and estimated using the Mantel-Haenszel method, standardizing for age (younger than 2 years, 2 years or older) and sex.¹ Ninety-five percent confidence intervals for each relative risk estimate were derived using the method of Miettinen.² For some factors, the relative risk changed with increasing exposure. We used an extension of the Mantel-Haenszel method³ to test for a linear trend of changing relative risk.

RESULTS

Table 1 shows the frequency and relative risk for each of the interview variables. Patients and control subjects were similar in all socioeconomic and demographic categories. There were no significant differences in birth weight, early feeding patterns, the use of nighttime bottles, or daily exposure to other children. Exposure to five or more household cigarette smokers increased the risk for PNEE

Table 1.—Relative Risk of Persistent Middle-Ear Effusion (PNEE) According to Interview Variables

Characteristic	No. (%) of PNEE Cases (n=76)	No. (%) of Surgically Subjected Controls (n=76)	Relative Risk*	95% Confidence Interval†
Demographic				
Sex				
M	46 (60.5)	46 (60.5)	1.0	...
F	30 (40.0)	30 (40.0)	1.0	...
Race				
White	66 (86.8)	66 (86.8)	1.0	...
Nonwhite	10 (13.2)	10 (13.2)	1.0	...
Household size				
≤2	64 (84.2)	62 (82.0)	1.0	...
≥3	12 (15.8)	14 (17.0)	0.8	0.4-2.3
Salaries				
0	34 (45.0)	17 (22.4)	1.0	...
≥1	62 (82.4)	60 (77.6)	0.8	0.5-1.5
Health Insurance				
Private	61 (80.7)	58 (73.7)	1.0	...
Medicaid	15 (20.0)	18 (23.3)	1.4	0.6-3.6
Infant care				
Birth weight				
≥2,500	71 (93.4)	72 (94.7)	1.0	...
<2,500	5 (6.6)	4 (5.3)	1.2	0.2-5.9
Fed 6 mo				
Breast-fed only	23 (30.3)	21 (27.6)	1.0	...
Formula-fed only	33 (43.4)	30 (39.6)	1.1	0.6-2.7
Supplies bottles (first 12 mo)				
Never used	47 (61.8)	62 (82.0)	1.0	...
≥6 nights per week	29 (38.2)	21 (27.7)	1.2	0.6-2.4
Daily exposure to other small children				
None	27 (44.7)	26 (47.4)	1.0	...
At home only	14 (18.4)	10 (13.2)	1.4	0.5-3.9
At home and away	26 (33.9)	20 (26.4)	0.8	0.4-1.5
Infant exposure				
Household cigarette smokers‡				
0	30 (39.5)	46 (60.5)	1.0	...
1	10 (13.2)	10 (13.2)	1.0	0.4-2.1
≥2	10 (13.2)	10 (13.2)	2.5	1.1-7.0
Household cigarette non-smokers§				
None	30 (39.5)	46 (60.5)	1.0	...
1-4	11 (14.5)	7 (9.2)	1.0	0.7-3.5
5-10	10 (13.2)	14 (18.4)	1.1	0.5-2.6
20-25	7 (9.2)	6 (7.9)	1.0	0.3-3.1
≥25	7 (9.2)	2 (2.6)	4.1	0.9-19.2
Otitis media				
Suppurative otitis media, 1 episode				
None	2 (2.6)	21 (40.0)	1.0	...
1-2	10 (13.2)	20 (26.3)	0.8	0.5-1.3
3-4	12 (15.8)	10 (13.2)	0.1	2.3-20.2
≥5	22 (28.9)	32 (42.1)	0.8	0.4-1.6
Age at first otitis, mo				
≤6	20 (44.7)	20 (79.2)	1.0	...
7-12	20 (26.3)	12 (15.8)	2.0	1.2-3.4
≥13	20 (26.3)	12 (15.8)	1.0	...
Family history of middle-ear disease				
Absent	47 (61.8)	53 (69.7)	1.0	...
Present	29 (38.2)	23 (30.3)	1.0	0.5-2.6
Maternal occupation (Last year for education)				
Frequency of symptoms, 1 day weekly				
None	31 (40.8)	27 (79.2)	1.0	...
≤5	10 (13.2)	6 (7.9)	2.6	1.0-6.6
6-10	10 (13.2)	6 (7.9)	0.8	0.3-2.3
>10	20 (26.3)	7 (9.2)	3.5	2.4-12.5
Atopic diseases (Last year for definition)				
Frequency of atopic symptoms, 5 days monthly				
None	54 (71.1)	60 (78.9)	1.0	...
1-10	7 (9.2)	6 (7.9)	1.0	0.4-3.6
>10	15 (19.7)	10 (13.2)	2.7	1.2-10.0

2024228152

Characteristic	No. (%) of PME E Cases (n=76)	No. (%) of Surplus Control Subjects (n=76)	Relative Risk*	95% Confidence Interval
Atopic disease (cont)				
Family history of atopic diseases	26 (48.0)	20 (47.4)	1.0	...
Atopic disease Present	61 (84.9)	60 (82.9)	1.1	0.9-2.0

*Standardized for age and sex by the method of Mantel and Haenszel.¹⁰

¹⁰Approximate limits, calculated by the method of Mantel.¹⁰

Mean age \pm SD was 3.52 ± 2.7 years for the PME E cases and 3.57 ± 2.6 years for control subjects. Mean

body weight \pm SD was 13.49 ± 8.1 g for PME E cases and 13.55 ± 8.6 g for control subjects.

¹¹Test for linear trend.¹¹

¹²Test for linear trend.¹² Comparing rates of increasing exposure (P=0.01).

¹³Test for linear trend.¹³ (P<0.01).

¹⁴Test for linear trend.¹⁴ (P<0.01).

Table 2.—Combined Effects of Risk Factors for Persistent Middle-Ear Effusions (PMEE)

Attribution	No. (%) of PME E Cases (n=76)	No. (%) of Surplus Control Subjects (n=76)	Relative Risk*	95% Confidence Interval
None	10 (12.0)	31 (40.8)	1.0	...
Only 1 factor	20 (26.3)	20 (43.4)	1.8	0.7-4.9
Congestion (>1 day a month)	14 (18.4)	7 (9.2)	2.3	1.3-11.5
Smoking (>0.5 packs per day)	13 (17.1)	22 (28.9)	1.1	0.5-2.9
Atopy (>1 day a month)	1 (1.3)	4 (5.2)	0.5	0.05-4.8
2 factors combined	10 (13.0)	8 (10.5)	4.8	1.7-12.8
Smoking and congestion	11 (14.5)	8 (10.5)	4.3	1.9-12.9
Smoking and atopy	1 (1.3)	0 (0.0)
Congestion and atopy	7 (9.2)	2 (2.6)	4.5	1.1-18.7
All 3 combined	13 (17.2)	4 (5.2)	8.3	1.9-21.1

*Standardized for age and sex by the method of Mantel and Haenszel.¹⁰

¹¹Test for linear trend comparing rates, sex, race, and three factors (P<0.001).

¹²Approximate limits, calculated by the method of Mantel.¹⁰

nearby threshold. With household exposure to smoke from two or three packs of cigarettes per day, the risk increased fourfold.

Nearly all of the patients with PME E had one or more previous episodes of suppurative otitis media. A significant trend of increasing relative risk occurred with increasing frequency of otitis media. When the first episode of otitis media occurred at younger than 6 months of age, there was an apparent threefold risk for PME E. However, if the age at the first episode of otitis was standardized for the total number of episodes, the relative risk was only 1.5 (95% confidence interval, 0.6 to 4.5). Thus, early otitis media may increase the risk for more frequent episodes of suppurative otitis, but of itself does not significantly increase the risk for PME E. A family history of ear dis-

ease increased the risk less than twofold, but despite this modest elevation, families with three or more affected members occurred only in the PME E group.

Nasal congestion occurred more often, and was more persistent, in children with PME E. With more persistent catarrh the risk increased from threefold to fivefold. Atopic diseases occurred twice as often in children with PME E. In those who required repeated tympanostomy-tube insertion, ten (48%) of 21 had atopic disease. The risk for PME E increased nearly fourfold in children with persistent atopic symptoms. A family history of atopic disease did not increase the risk for PME E.

Table 2 shows the combined effects of nasal congestion, cigarette smoke exposure, and atopy. Nasal congestion alone elevated the risk nearly four-

fold. When cigarette smoke exposure to any was added to nasal congestion, the risk increased. Children with all three factors were more than six times as likely to manifest PME E.

COMMENT

Suppurative otitis media, catarrh, and middle-ear effusions are common childhood conditions. The risk of these conditions is increased in children with certain factors, and atopy is an important risk factor. Several clinical and laboratory studies would substantiate the importance of these factors. Recurrent infections can damage ciliary function and cause metaplastic changes in middle-ear mucous glands.¹¹ The altered mucous secretes a thick, glue-like fluid, which is more likely to persist for long periods. Catarrh, which occurs more commonly in children with abnormal middle-ear pressures,¹² may reflect repeated nasal infections, nasal irritant reactions, or nasal allergy. Each of these conditions could cause mucosal edema, hypersecretion, and abnormal ciliary function, which then results in obstruction or "dysfunction" of the eustachian tubes. Family studies of cigarette smoke exposure have shown that the risk of middle-ear effusions is increased in heavily exposed children. Catarrh becomes more persistent in children with atopic disease, allergic rhinitis is the likely cause of their increased risk of middle-ear effusions. Recent studies in patients with allergies have shown that nasal challenges with specific antigens can produce sustained abnormalities of eustachian tube function.¹³

Recurrent otitis media, nasal catarrh, cigarette smoke exposure, and nasal allergies are all clinically linked. The nasal and middle-ear cavities, causing persistent eustachian tube dysfunction. Middle-ear effusions will clear less readily in heavily exposed children, which may eventually necessitate surgical drainage and insertion of tympanostomy tubes. These children may need treatment of their allergies to achieve the elimination of factors remote from the domestic environment and, if atopic disease is present, the control of specific environmental allergens.

This study was supported by a grant from the Children's Orthopedic Hospital and Medical Center Research Fund R572, and by Associated Scientists to Help Minimize Asthma (ASTHMA) Inc. Seattle.

James Donabedian, MD, Earl Anderson, RN, and Donna Lavery provided help in contacting patients. The physicians, surgeons, and support staff of the Children's Orthopedic Hospital and Medical Center, Seattle, provided assistance in contacting control subjects. Nancy Kraemer assisted in preparation of the manuscript.

References

1. Sherris PA, Patton EL, Danner A, et al: Persistence of middle-ear effusion after acute otitis media in children. *N Engl J Med* 1979; 300:1121-1125.
2. Teich DR, Rosner BA, Etkin JC: Epidemiology of otitis media in children. *Ann Otol Rhinol Laryngol* 1980;89(suppl)5:4.
3. Tei M, Paulsen G, Berch J: Etiologic factors in secretory otitis. *Arch Otolaryngol* 1976; 104:452-458.
4. Sorenson CH, Holm-Jensen S, Tei M: The post-viral persistence rate of middle ear effusion in 4-year-old children, judged by tympanometry. *Int J Pediatr Otolaryngol* 1981;13:115-122.
5. Tei M, Paulsen G, Haasch AE: Screening tympanometry during the first year of life. *Arch Otolaryngol* 1973;81:285-294.
6. Tei M: Frequency of secretory otitis and history of the normal middle ear disease. *Int J Pediatr Otolaryngol* 1979;13:11-24.
7. Tei M, Holm-Jensen S, Sorenson CH, et al: Spontaneous course and frequency of secretory otitis in 4-year-old children. *Arch Otolaryngol* 1982;108:4-10.
8. Bluestone CD, Berry GC, Paradise JL: Autismy and tympanometry in relation to middle ear effusions in children. *Laryngoscope* 1973;83:94-99.
9. Henric VM: Developmental sequence of chronic otitis media: A review. *Dent Radiol Pediatr* 1981;34:28.
10. Paradise JL: Otitis media during early life: How hazardous to development? A critical review of the evidence. *Pediatrics* 1981;68:859-872.
11. Paradise JL: On tympanometry, subjective, routine, results, interpretation, and recommendations. *Pediatrics* 1977;60:84-90.
12. Kanner DM, Snow CM, Singer J: *Assessment of Medical Care for Children: Continuum in Health Status*. Washington, DC, Institute of Medicine, National Academy of Sciences, 1974, pp 28-34.
13. Kabbio E: Chronic secretory otitis media in children: A clinical study. *Ann Otolaryngol* 1974;82(suppl)6:44.
14. Sorenson E: Otitis media in young children in different types of day-care. *Scand J Infect Dis* 1973;119-123.
15. Sauerwald WC: Positional otitis media. *J Pediatr* 1971;79:284-286.
16. McGovern JP, Haywood TJ, Paradise AA: Allergy and secretory otitis media: An analysis of 512 cases. *JAMA* 1981;200:124-128.
17. Bernstein JM, Bateman E: The role of acute hypersensitivity in secretory otitis media. *Trans Am Acad Ophthalmol Otolaryngol* 1974; 74:120-127.
18. Mantel N, Haenszel W: Statistical aspects of the analysis of data from retrospective studies of disease. *JNCI* 1959;22:719-748.
19. Miettinen O: Estimability and estimation in case-referent studies. *Am J Epidemiol* 1976; 103:225-233.
20. Mantel N: Chi-square tests with one degree of freedom: extensions of the Mantel-Haenszel procedure. *J Am Stat Assoc* 1958; 54:600-701.
21. Sade J: Infectious and non-infectious factors related to secretory otitis media. *Int J Pediatr Otolaryngol* 1973;4:49.
22. Harlap S, Davies AH: Infant admissions to hospital and maternal smoking. *Lancet* 1974; 1:589-592.
23. Donabedian OB, Wilson BW: Children's health in families with cigarette smokers. *Am J Public Health* 1981;71:280-283.
24. Hagg JC: Breach of normal permeability and its relationship to allergy hypersensitivity. *J Allergy Clin Immunol* 1981;57:421-425.
25. Orr H, Leong A, O'Connor R, et al: Middle ear pressure changes following nasal antigen challenge. *J Allergy Clin Immunol* 1981; 67(suppl)13.
26. Friedman R, Doyle W, Paris J, et al: Immunologic mediated obstruction tube dysfunction (ETD). *J Allergy Clin Immunol* 1982; 66(suppl)16.

2024228154